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JENEBERANG RIVER FLOOD CONTROL PROJECT (PHASE II)

SUPPORTING REPORT-I

DAM AND RESERVOIR
RIVER IMPROVEMENT
PROJECT ECONOMY

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JAPAN INTERNATIONAL COOPERATION AGENCY

1. DAM AND RESERVOIR

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1. GENERAL

The dam whose construction is proposed at Bili-Bili will be designed as a multi-purpose dam which is equipped with the maximum possible storage capacity techno-economically justifiable under the given natural conditions. The storage capacity to be developed will be allocated on the priority basis as mentioned below:

Primarily, the reservoir shall be equipped with proper storage capacity to regulate the flood discharge which may inflict damages on the downstream area.

Secondly, the reservoir will have storage capacity, in order to contribute to the welfare of the citizens of Ujung Pandang and to answer social demands felt by them, to make dependable supply of raw water for distribution among them as municipal and industrial water.

Thirdly, the remaining part of the storage capacity will be allocated for irrigation purpose to raise agricultural productivity in the down stream irrigation area.

As for the hydro power generation, it will also be formulated by using the municipal and industrial water, and the irrigation water from the proposed reservoir.

2. FORMULATION OF PROPOSED DAM

2.1 Site Selection

In the preceding study, three possible dam sites were nominated along the Jeneberang river course; they are Bili-Bili, Pasaratowaya and Jonggoa, being situated upstream from the estuary of the river at 31 km, 44 km, and 53 km, respectively, and besides, there is Pattalikang on the Jenelata river at 2.5 km upstream of the confluence of Jeneberang river. These four possible dam sites are shown in Fig. 1-1.

A comparison of principal features relative to the proposed dam and reservoirs at the respective sites is shown in Table 1-1.

The main purpose of this project is to work out flood control measures over the downstream areas of the Jeneberang river.

Bili-Bili dam site was found as the most advantageous of the four proposed dam sites because the storage effect is higher, the catchment basin is larger and the construction cost is lower.

From the viewpoint of the flood control project of the entire basin, the construction of a flood control dam on the Jenelata together with the construction of Bili-Bili might be effective because the catchment basins of Bili-Bili and Pattalikang are 384.4 km^2 and 226.3 km^2 respectively, and this constitutes about 84% of the total catchment basin of the Jeneberang river, as the result, they will be easily able to control the flood water.

In this connection, study of the case where both dam construction and river improvement works are operated together for flood control was made to find out the optimum share of flood control among the above three methods.

The most economical share among these methods is that the river channel will confine 2,300 m^3/sec. of discharge, and the required flood control capacities of Bili-Bili and Pattalikang are 28 x $10^6 m^3$ and 16 x $10^6 m^3$ respectively (refer to Fig. 1-2).

However, combined construction cost of the two dams and river improvement is about 1.6 times higher than the cost of Bili-Bili dam construction and river imrovement (refer to Fig. 1-3).

Furthermore, the design discharge of a 50-year return period can be controlled only by the proposed Bili-Bili dam and river improvement works.

So, from the economic and technical viewpoints mentioned above, it is appropriate to construct a dam at Bili-Bili site on the Jeneberang river for the flood control purpose.

2.2 Design Flood for Spillway

The figure which ranks the highest among those calculated by the following methods should be adopted as Bili-Bili dam's design flood discharge.

1) Flood discharge of 1000-year probability;
   4,300 m^3/s

2) Flood discharge of 200-year probability x 1.2;
   3,900 m^3/s

3) The past maximum flood discharge (on Feb. 5, 1967);
   2,244 m^3/s

4) Regional specific discharge

Regional specific discharge under 4. above, however, has not yet been established in Indonesia and, only the specific discharges of the dams in Indonesia as shown in Fig. 1-4 are compared with the design flood for spillway decided by the above methods of 1, 2 and 3, for reference.

Consequently, 4,300 m^3/s which corresponds to the flood discharge of 1000-year probability has been adopted as Bili-Bili dam's design flood discharge. This shall be equated to the outflow discharge from its spillway without taking into consideration the regulating function of the reservoir. The design flood discharges of the dams existing or under construction in Indonesia are shown in Table 1-2, for reference.

2.3 Development Scale of Bili-Bili Dam and Reservoir

The utmost priority is given to safety of a dam where a huge volume of water is impounded. A failure of the proposed dam definitely results immeasurable damage to lives and assets of the downstream inhabitants of the project area including Ujung Pandang with the population of about 700,000.

Under the above situation, the crest elevation and design flood water level have been fixed at EL. 105 m and EL. 102 m respectively as the highest allowable from the viewpoint of safety followed by technical justifications as mentioned below, though from the economic viewpoint, a slightly higher crest elevation may be effective. (Refer to Fig. 1-5)

If the crest elevation exceeds EL. 105 m, it calls for adequate considerations, especially at areas where saddles, EL. 103 m in average, are located, one on the axis of the spillway and three others about 5 km upstream of the dam site.

Additional construction works such as mentioned below shall be required when the crest elevation at EL. 105 m or above.

1) Dam site

- A concrete abutment on the right bank of the left wing dam
- Concrete foundation, about 250 m and 80 m in width on the left and right side portions respectively of the spillway overflow section of about 500 m in overall width.

2) Reservoir

- Sub-dam of about 1,500 m in overall length consisting of sections 700, 500 and 200 m for overflow protection.

A further increase in the reservoir storage even at the cost of such extra countermeasures mentioned above will bring some adverse effects on the safety of the dam. And also, after the completion of the dam, it is required to maintain a closer administration over a wide area of the dam and the reservoir.

In the case of the crest elevation at EL. 105 m, the saddle areas are fully secured by a low embankment. The relocation road may be routed to cross the saddle area on the embankment.

Utilizable Reservoir Capacity

The effective storage capacity developed by the Bili-Bili dam will be allocated in below.

Flood control capacity has to be determined at in combination with the river improvement works to be effected in its downstream. Based on the findings of the study under 4.1 in the supporting report of "RIVER IMPROVEMENT", Bili-Bili reservoir should be provided for the flood control capacity of 46×10^6 m^3.

The storage capacity for water utilization is seriously influenced by the type of spillway when the dam height is fixed. To determine the water utilization capacity for the Bili-Bili dam, the following five types of spillway have been studied (refer to Fig. 1-6).

Type I : Single free flow section

Type II : Double free flow section

Type III : Single free flow section with regular gates

Type IV : Double free flow section with regular gates

Type V : Single free flow section with regular gates as well as emergency gates.

Through the comparative study, it has been verified that the spillway type IV, which is provided with a double free section with two regular gates, is the optimum for the below-mentioned reasons. Thus, the proposed Bili-Bili dam will secure a water utilization capacity of 258×10^6 m^3.

Study Results of the Spillway Type

The comparative study has been made from various angles such as safety factor, technicality (operational and functional) and economicality as follows:

1) General consideration

While the type of spillway should be determined from both technical and economical viewpoints, a greater weight would have to be given to the former in view of securing the safety of dam body and avoiding flood damages in the downstream area.

2) Technical consideration

Spillway type I, II, III and IV are equally capable of satisfying the safety and flood control requirements. The regular gates provided for the spillway types III and IV are not supposed to cause any problem in passing the flood water as they need to be operated only for the discharge below 500 m^3/s which is nondamage flow towards the downstream area, and in case the discharge happens to surplass 500 m^3/s, they will be completely opened. As for spillway type V, however, an orderly operation of the gate is required to discharge flood water from the proposed reservoir, which means that it is not completely free from accidents liable to misoperation and/or mechanical trouble with the gate. In this sense, the spillway type V is supposed to be less advantageous to the other types.

3) Economic consideration

Since there is no significant difference in construction cost among these five types of spillway, as indicated in Table 1-3, the one which can afford the more reservoir capacity for water resources development purpose will prove itself the more economical. Consequently, it has been concluded that the spillway type V is the most economical, to be followed by the type IV.

Safety factor being taken into consideration, the type IV remains as the best.

2.4 Bili-Bili Reservoir

The main features of Bili-Bili Reservoir are as follows:

Design flood water level (D.F.W.L.)	EL. 102.00 m
Surcharge water level (S.W.L.)	EL. 100.30 m
Normal water level (N.W.L.)	EL. 97.60 m
Low water level (L.W.L.)	EL. 74.00 m
Effective water depth (S.W.L.-L.W.L.)	26.30 m
Reservoir surface area at S.W.L.	17.8 km^2
Total storage capacity	362 x 10^6 m^3
Effective storage capacity	304 x 10^6 m^3
Flood control capacity	46 x 10^6 m^3
Capacity for water utilization	258 x 10^6 m^3
Municipal and industrial water	17 x 10^6 m^3
Irrigation water capacity	241 x 10^6 m^3
Sediment capacity	58 x 10^6 m^3

Relation between the reservoir surface area and the storage capacity is shown in Fig. 1-7. Allocation of the reservoir capacity is illustrated in Fig. 1-8.

Flood Control Capacity

Storage of 46 x 10^6 m^3, between EL. 97.60 m and EL. 100.30 m, is secured for the purpose of flood control.

This capacity is able to regulate 1,300 m^3/s out of 2,400 m^3/s at the dam site (refer to Fig.1-9).

Water Utilization Capacity

The allocated 2.3 m^3/sec of municipal and industrial water is released from the storage all through the year. Storage of 17 x 10^6 m^3 is specially earmarked for the supply during dry season.

Storage of 241 x 10^6 m^3 is specially secured for the irrigation water during dry season.

The storage capacities mentioned above are computed on the basis of the conditions as shown below.

Evaporation, Reservoir surface	:	3.0 mm/day
Discharge loss in river	:	3.0%

Hydro power generation principally depends on municipal and industrial water, and irrigation water, and only when more water for recovery of the reservoir storage is available during rainy season, the surplus will be utilized for hydro power generation.

In early May every year, the reservoir is at the full. After then, with a decrease of inflow, storage water is released to maintain the required water.

Schematics of water utilization and the variation of reservoir water level are shown in Figs. 1-10 and 1-11 respectively.

Sediment Capacity

The sediment capacity is 58×10^6 m^3, corresponding to the 100 year's inflow of sand into the reservoir.

3. PRELIMINARY DESIGN

3.1 Dam

Its type shall be the central core rockfill dam. Dam consists of main dam which connects two hills, and two wing dams on the right and the left. The main dam will be built to shut down the Jeneberang river, and the right wing dam is to close a saddle through which Jl. Malino is running and the left wing dam is to shut down a saddle which is situated on the watershed deviding the Jeneberang river basin from the Jenelata river basin.

The principal features of each dam are as follows:

		Main dam	Left wing dam	Right wing dam
Height	:	66.00 m	40.00 m	50.00 m
Length	:	670.00 m	725.00 m	440.00 m
Crest width	:	10.00 m	10.00 m	10.00 m
Crest elevation	:	EL.105.00 m	EL.105.00 m	EL.105.00 m
Dam volume	:	3,600,000 m^3	1,350,000 m^3	1,330,000 m^3

The aggregated total volume of these three dams will be 6,280,000 m^3, including 1,000,000 m^3 which is the coffer dam volume.

The dams and their appurtenant facilities are shown in Figs. 1-12, 1-13, 1-14 and 1-15.

Dam Type

Regarding the type of the dam above, rockfill type with a center core has been adopted due to the following reasons:

1) Geologic Viewpoint

Foundation rock at the dam site is largely made up of the sedimentary rocks belonging to the geological age of Neogene Tertiary which are being partially penetrated by dike rocks consisting of diabase and microdiorite. While diabase and microdiorite have sufficient strength to serve as the foundation of a concrete dam, calcareous mudstone/sandstone and tuff which are spreading rather widely in parts of the riverbed and in the neighborhood of the foundations for the both wing dams do not warrant a strong foundation for concrete dam.

2) Topographic Viewpoint

The topographic condition ruling in its site is decisive in selecting a type of dam to be built there. When the "Shape of Factors" (the ratio of crest length to crest height) remains less than 4-5, it is generally believed advantageous to adopt a concrete dam because it can do with small dam volume. In case of Bili-Bili, however, fill type dam is more suitable to its topography because the "Shape of Factors" turns to be 11.4 with the main dam, 15.8 with the left wing dam, and 8.2 with the right wing dam.

3) Material Viewpoint

Availability of construction material within an easy reach of the dam site is one of the necessary conditions for deciding at a fill type dam. The geological survey conducted at, and in the vicinity of, the dam site made it clear that the good quality materials for fill type dam are available. For instance, impermeable core material can be met with the spoils of spillway excavation, filter materials are abundantly available from the riverbed gravels, and diabase and microdiorite being distributed in the downstream of dam site can be used as rock material.

4) Technical Viewpoint

Among the dams, homogenous earth dam is given the upper limit of 30 m in dam height, while an inclined core type is out of choice in the case of Bili-Bili dam which will then require a huge dam volume. This is because the upstream slope of the dam with inclined core is required to be very mild, as the valley opens extemely wide towards upper stream.

Freeboard of Dam

The freeboard of 2.4 m provided above the design flood water level includes the following:

Wind wave	:	0.9 m
- Wind velocity (10 min. average)	:	20.0 m/s
- Max. fetch of reservoir	:	6.0 km
Allowance for misoperation of gates	:	0.5 m
Freeboard specifically provided for fill type dam	:	1.0 m
Total	:	2.4 m

Consequently, considering a protection for the impervious core and the thickness of crest road, the crest elevation has determined at EL. 105.00 m.

Crest Width

The width of the crest is fixed at 10 meters taking safety for waves, seepage, the width required for execution of the work and utilization of the crest into consideration.

Some actual examples of the similar type dams in Indonesia are given below:

		Width	Height of dam
Karangkates Dam	:	13.7 m	100.0 m
Wonogiri Dam	:	10.0 m	38.0 m
Wlingi Dam	:	8.0 m	28.5 m
Sempor Dam	:	10.0 m	50.0 m

Slope Protection

Riprap, pitching, concrete blocking, etc. are generally used in the slope protection work but here the riprap is adopted for reasons as mentioned below:

- Material is low in cost
- Creeping up of the wave on the slope is less compared with the cases of pitching and concrete blocking, therefore, the height of the dam can be designed lower

Riprap is placed over the upstream slope of the dam body. The thickness of the layer is 1.0 meter.

As the slope is exposed to severe conditions such as waves, wind, rain, temperature fluctuation, drawdown of the reservoir water level etc., the purpose of riprap is to protect the embankment materials from moving and washing out by wave action.

Stability Analysis of Dam Body

The stability analysis of dam is carried out for the preliminary design of embankment section of checking on sliding failure.

The safety against sliding failure shall be examined, as a rule by applying the slice method to the slip circle surface.

The factor of safety is obtained by the following formula:

$$n = \frac{\Sigma\{Cl + (N - U - Ne)\tan\phi\}}{\Sigma(T + Te)}$$

where

- n : factor of safety
- N : normal force acting on slip circle of each slice
- T : tangential force acting on slip circle of each slice
- U : pore pressure acting on slip circle of each slice
- Ne: normal force of earthquake load acting on slip circle of each slice
- Te: tangential force of earthquake load acting on slip circle of each slice
- ϕ : angle of internal friction of materials on slip circle of each slice
- c : cohesion of materials on slip circle of each slice
- l : arc length of slip circle of each slice

The safety factor shall be more than 1.2.

Stability calculation was made for the following cases:

1) Design flood water level without earthquake acceleration

2) Surcharge water level without earthquake acceleration

3) Surcharge water level with earthquake acceleration (Ea = 0.05)

4) Normal high water level without earthquake accelertion

5) Normal high water level with earthquake acceleration (Ea = 0.10)

Assumptions and constants used in the analysis are given below:

1) Unit weight of water 1t / m^3

2) Density of embankment materialks

Core material	Wet	γ_t	= 1.80 t/m^3
	Saturated	γ_{sat}	= 1.88 t/m^3
Filter material		γ_t	= 1.98 t/m^3
		γ_{sat}	= 2.20 t/m^3
Random material		γ_t	= 2.00 t/m^3
		γ_{sat}	= 2.10 t/m^3
Rock material		γ_t	= 1.85 t/m^3
		γ_{sat}	= 2.15 t/m^3
River bed material		γ_{sat}	= 2.10 t/m^3

3) Angle of internal friction of materials

Core material	ϕ = 30°
Filter material	ϕ = 35°
Random material	ϕ = 35°
Rock material	ϕ = 37°
River bed material	ϕ = 35°

4) Design flood water level EL. 102.00 m
Surcharge water level EL. 100.30 m
Normal water level EL. 97.60 m

5) Crest elevation of main dam EL. 105.00 m
Crest elevation of coffer dam EL. 71.00 m

The calculation was made for typical cross section of dam varying the slope of embankment. As the result, the slope gradient was determined as 1 : 2.6 for the upstream and 1 : 2.0 for the downstream faces.

The result of stability analysis are shown in Fig. 1-16(1), (2), and (3).

Foundation Treatment

The rock-bed of the proposed dam site has a sufficient bearing capacity for a foundation of a fill dam.

As to the permeability, the dam foundation rock is generally impervious. Consequently, for the foundation treatment, adoption of generally accepted grouting is planned.

1) Curtain Grouting

Curtain grouting is placed along the foundation of the impervious core of the dam to prevent leak through the foundation and to eliminate uplift observed in the down stream side of the dam body.

Grouting by cement milk will be adopted. The depth of curtain grout, location of grout holes are determined by taking into account depth of reservoir, kinds of rocks and Lugeon map, etc.

In curtain grouting, grout holes are located in parallel with the grout line in 2 rows and at an interval of 3.0 meters, except of 1.5 meter around the abutments of the left and right wing dams where permeability is higher.

2) Branket Grouting

For the purpose of prevention of leak through joints and fissures, shallow branket grouting is placed. In branket grouting, grout holes, 5.0 meters each in depth, are located in parallel with the grout line in 4 rows and at an interval of 2.5 meters.

3.2 Spillway

Type and Function of Spillway

Spillway will be installed on an elevated ground standing between the main dam and the left wing dam. The principal features of the overflow section of spillway are mentioned below.

Free flow section	:	100 m wide, EL.97.60 m
Free flow section	:	337 m wide, EL.100.30 m
Regular gate	:	2 gates x 6.5 m wide x 7.5 m high

These features have been determined based on the under-mentioned conditions:

1) In case the discharge at the dam site happens to be below 500 m^3/s, the spillway gates will be operated to discharge surplus water in order to maintain the reservoir water at the normal water level (N.W.L. 97.60 m);

2) In case the discharge happens to be above 500 m^3/s at the dam site, the flooding water will be naturally regulated without operating spillway gates. Accordingly, design flood for down steam area will be discharged at the surchage water level (S.W.L. 100.30 m) so as it will be regulated to 2,300 m^3/s at Kampili point;

3) The flood discharge designed at 4,300 m^3/s will be made an outflow discharge at the design flood water level (D.F.W.L. 102.00 m).

Overflow discharge at the spillway is computed by the formula below.

$$Q = C \times B \times H^{3/2}$$

where

Q : overflow discharge (m^3/sec)
C : coefficient of discharge (2.0 const.)
B : overflow width (m)
H : overflow depth (m)

Based on the condition, 1) in the foregoing, to allow discharge of 500 m^3/sec under the full-open gate:

$$B = 6.5 \text{ m} \times 2 = 13.00 \text{ m}$$
$$H = \text{N.W.L. } 97.60 - \text{EL } 90.40 = 7.20 \text{ m}$$

therefore

$$Q = 2.0 \times 13.00 \times 7.20^{3/2} = 502 \text{ m}^3/\text{sec} > 500 \text{ m}^3/\text{sec}$$

The answer to the condition, 2) in the foregoing, will be obtained from the flood control computation taking the storage effect of the reservoir. The results of the computations are given in Fig. 1-17.

Based on the condition, 3) in the foregoing, the flow capacity against the design flood discharge of the dam was checked up as shown below.

Regular gate (Q_1)

$$B = 6.50 \times 2 = 13.00\text{m}, \quad H = \text{EL } 102.00 - \text{EL } 90.40 = 11.60\text{m}$$

$$Q = 2.0 \times 13.00 \times 11.60^{3/2} = 1{,}027 \text{ m}^3/\text{sec}$$

Regular free overflow (Q_2)

$$B = 100 \text{ m}, \quad H = \text{EL}102.00 - \text{EL } 97.60 = 4.40 \text{ m}$$

therefore

$$Q_2 = 2.0 \times 100 \times 4.40^{3/2} = 1{,}845 \text{ m}^3/\text{sec}$$

Emergency free overflow (Q_3)

$$B = 337 \text{ m}, \quad H = \text{El } 102.00 - \text{EL } 100.30 = 1.70 \text{ m}$$

therefore

$$Q_3 = 2.0 \times 337 \times 1.70^{3/2} = 1{,}493 \text{ m}^3/\text{sec}$$

Therefore, the total discharge is as shown below

$$Q = Q_1 + Q_2 + Q_3 = 4{,}365 \text{ m}^3/\text{sec} > 4{,}300 \text{ m}^3/\text{sec}$$

The capacity of spillway will be, as described in the foregoing, sufficient to discharge 4,300 m^3/sec.

3.3 Diversion Channel

The temporary diversion channels have been given design discharge of 1,850 m^3/s without any regulation of flood in the reservoir which corresponds to a flood dischage of 20-year probability that is generally adopted for rockfill dam construction.

After completion of a coffer dam, a regulation effectiveness against flood discharge can be expected as shown in Fig. 1-18.

Selection of Type

For the proposed temporary diversion channel, tunnel and open channels may be mentioned as suitable. Their proposed locations are shown in Fig. 1-19, and the following is brief description of three proposed cases.

Plan 1 The tunnel type diversions will be located below the left abutment of the main dam. Two tunnels will be bored (in parallel) and the diameter is 9.0 meters each. The No. 1 tunnel, to be located along the riverside, and the No. 2, to be located near to the mountain, are 260 and 280 meters in length respectively.

Plan 2 The open type diversion channel will be located on the right bank and along Jl. Malino. The channel will be divided into conduit section through the dam foundation (diameter 9.0 m, length 300 m, 2 conduits), and the open channel section (channel bed width 60.0 m, length 800 m), to avoid hindrances to embankment work of the right wing dam.

Plan 3 The open type diversion channel will be located on the left bank of the abutment along the river (diameter 9.0 m, length 300 m, 2 conduits).

With regard to the temporary diversion channel for the proposed dam, a tunnel type is adopted because of the reasons mentioned below.

1) No structural weakpoint will remain in the dam foundation, contrary to the case of the open channel type.

2) Construction cost is estimated at US$12.2 million which is less than the estimated cost of open channel. The construction cost of Plan 2 is estimated at US$13.8 million and Plan 3 at US$12.8 million.

3) After the completion of the proposed dam, the channel can be utilized to an outlet facilities. This offers advantages in cost-wise as well as in the schedule of the construction works.

Size of Diversion Channel and Coffer Dam

The crest height of the main coffer dam has an interrelation with the bore of the temporary diversion tunnel.

The sizes of the diversion tunnel and coffer dam are decided from the economical comparison.

The main coffer dam has been designed to have a height of EL.71.00 m and an embankment volume of 1,000,000 m^3, which will be included in the embankment volume of the main dam and the right wing dam from a economical point of view as mentioned below.

Item	Plan I	Plan II	Plan III
Tunnel, dia. (m)	8.0	9.0	10.0
Main coffer dam crest EL. (m)	81.2	71.0	65.0
Volume of main coffer dam embankment (x 10^3 m)	2,200	1,000	600
Construction cost (x 10^3 US$)			
- Diversion tunnel	10,600	12,800	17,900
- Coffer dam embankment	13,800	6,300	3,800
Total	24,400	19,100	21,700

3.4 Intake Facilities

The supply from the reservoir is mainly municipal and industrial water and irrigation water.

The intake facility should be designed to allow the intake of the total of the above-mentioned, 32.0 m^3/sec., max., at the lowest low water level of the reservoir.

For the intake, an inclined conduit is constructed above the No. 2 temporary diversion tunnel running through the abutment of the left bank of the main dam.

The intake tower of reinforced concrete construction is 11.00 m in width and 36.00 m in height with an incline angle of 45 degrees.

A steel screen is placed in the front face of the intake tower, and at the inlet of the intake, one roller gate, 4.00 m in width, and 5.00 m in height is installed.

The temporary diversion tunnel, after completion of the dam, will be reused for the purpose of the intake channel instead of the construction a new intake for the utility water to save the project cost.

Accordingly, the intake water runs through the temporary diversion tunnel and, than lead to the power plant through a steel pipe, from the plugged section in the diversion tunnel.

3.5 Outlet Facilities

The outlet facilities for the respective purposes as mentioned below are located in the power plant housing.

For the outlet facilities, the gates of the specifications below are installed.

1) Municipal water

Jet-flow gate: 0.5 m. dia.

2) Irrigation water

Jet-flow gate: 1.5 m. dia.

Normally, these gates are closed, and the demand water is supplied through the tailrace. The gates are opened only when the power plant is not in operation.

Besides the outlet facilities as mentioned above, one jet-flow gate, 2.0 m. dia., has to be installed in order to lower the reservoir water stage for inspection and maintenance in case of emergency. The gate and its operating room will be placed in the No. 1 temporary diversion tunnel.

3.6 Division Works

Tail water from the power station is divided into supply purposes intended while flowing in the tail water channel.

For a steady control of the intake water for the respective purpose, the control gates are installed at the end of the tailrace channel.

Two intakes with the sluice gate are provided on the side-wall of the tail water channel above the control gate.

All the water mentioned in the foregoing is conveyed to the areas on the right bank of the river through individual conduits for the respective supply purposes.

Major features of the diversion gates are as follows

Item	Width	Height	Number	Remarks
Control gate	3.5 m	2.0 m	2	Kampili irrigation & vested right water
Intake gate	1.0 m	1.0 m	1	Municipal water & sericulture water
Intake gate	2.0 m	2.0 m	1	Bili-Bili irrigation water

3.7 Land Acquisition and Relocation

Land Acquisition and House Evacuation

A land of 1,591 ha shall be acquired and 790 houses shall be evacuated due to implementation of the project.

Relocation of Road

Jl. Malino which is running along the right bank side upstream of the dam site will have to be relocated for a distance of 19 km.

The existing Jl. Malino satisfies the Class III, Road Construciton Standards. The width of the road consists of the asphalt pavement of 3.5 meters in width and right and left sides shoulders of 1.5 meters each.

Except this, there is no particular road to be relocated. Construction of new bridge is limited to small ones less than 5 m in width, simply to cross over brooks, in the number of 4.

Relocation of Pumping Station

The pump station belonging to the Sericultural center which is drawing the river water at dam site will need to be replaced.

The details of land acquisition and relocation related to the project implementation are set forth in Table 1-4.

4. CONSTRUCTION PLANNING AND COST ESTIMATE

4.1 Construction Schedule

Dam construction work will follow the stages as mentioned below:

1. Temporary diversion work (April 1986 - March 1987)
2. Coffer dam work (April 1987 - October 1987)
3. Left wing dam embankment (start) (April 1987)
4. Main dam embankment (start) (April 1988)
5. Right wing dam embankment (start) (July 1988)
6. Impounding of the reservoir (start) (November 1990)

An entire construction period will last for 5 years, from April 1986 to March 1991. The construction schedule covering all the stages is shown in Fig. 1-20.

4.2 Construction Method

Work Plan

The earth work involved in this dam construction is as much as 6,280,000 m^3 will need to be excavated at dam foundation and spillway.

Construction work will generally be performed by conventional methods. Excavation and collection of the materials for impervious core and filter will be mainly carried out by blading and ripping with bulldozers, loading with shovels and hauling with dump trucks.

Excavation of hard rocks will be performed by drilling and explosion. Bulldozers will be used for excavation of soft rocks.

Compaction of core material and filter zone which will be involved in the embankment work of dam will be carried out by tamping roller and vibration roller, respectively.

Concrete is produced by a central mixing plant of 40 m^3/hr capacity and concrete placing will rely on concrete pump cars and truck cranes.

Workable Days

Rockfill dam construction work largely consists of the earth work which is bulky in volume, concentrated in work load, and yet, needs fine quality in its finish. Such requirements having been taken into consideration, the workable days of a year for dam construction have been calculated based on the climatological, particularly rainfall, data available at the dam site (refer to Table 1-6 and 1-7). Job-wise workable days have thus been estimated as follows:

Excavation	:	263 days/year or 22 days/month
Core and filter material fill-up	:	142 days/7 months or 20 days/month
Rock and Random material fill-up	:	252 days/year or 21 days/month
Concrete work	:	225 days/year or 20 days/month

While the excavation, rock material filling and concrete works will be continously done all through the year, core and filter materials filling work will be suspended during wet season that is from November to March.

All of works expect during the peak rainy period are executed by two shifts system per day.

4.3 Construction Materials

Embankment Materials

Major portion of the dam construction work is earth work. The embankment work volume of a dam is 6.28 x 10^6 m^3 in grand total.

The below is the required embankment volume of dams by zones.

(Unit: x 10^3 m^3)

Item	Main dam	Left wing dam	Right wing dam	Total
Rock	2,050	910	830	3,790
Filter	480	150	170	800
Core	630	200	230	1,060
Randam	440	90	100	630
Total	3,600	1,350	1,330	6,280

The above-mentioned volumes include the cofferdam body of 1,000 x 10^3 m^3 each.

The findings of the present survey show core, rock and filter materials required for the dam embankment works are available at places within about 1.0 km from the dam site.

Sites of borrow pit and quarry which will be required for dam construction are indicated in Table 1-5, Fig. 1-21 and Fig. 1-22.

Aggregates for concrete, and fine aggregate for the filter material are available at the quarry about 10.0 km down stream of the dam site and mixed with the coarse aggregate (river bed gravel) available at the dam site.

Concrete Materials

All the concrete aggregates are entirely made up of the riverbed sands and gravels. For the dam construction work, the riverbed gravels at dam site will be utilized as the coarse aggregates and the river sands available from 10 km downstream of the dam site, as the fine aggregates. Much concrete volume is required for construction of the dam spillway and the temporary diversion conduits, each in the order of 127,000 m^3 and 33,000 m^3, respectively. The requirements for cement in the dam-construction work, including that for grouting work, amount to approx. 55,000 tons in total.

The demand of cement on the area market exceeds the supply from Tonasa Cement Factory by about 50%. (Forecast for 1983) The supply does not meet the demand appreciably. In the execution of such construction work as dam and power station, a large and uninterrupted supply of cement of high strength and uniform guaranteed quality is indispensable all during the period of the construction.

Consequently, in these circumstances, it might reasonably be supposed that the cement required for the construction of the proposed dam and power station may have to be imported

Local Materials

Steel bars, lumbers, bricks, stones, fuels and oils which are necessary as the construction materials in general are almost entirely obtainable locally.

Foreign Materials

Most of the hardware and equipment required for the work, such as cement structural steel, iron/steel pipes, water gates, valves and some other materials which need to be of high precision and good quality plus machinery and equipments will have to be imported.

4.4 Construction Machinery

The construction works covered under this project call for deployment of various kinds of construction machinery which are mostly to be imported except a few items being manufactured in Indonesia. Due to limitations and problems as for their performance, replacement of parts, and durable period, etc., it is difficult to expect transfer of the construction machinery which have been or are used elsewhere to this project which is comprised of dam requiring a considerable long period of time for their construction.

Under such circumstances, the construction machinery required for execution of this project will have to be imported anew in their majority.

Construction machinery which will be required for the dam construction are decided from conditions as mentioned below and set forth in details in Table 1-8.

Types and number required for the proposed embankment works are based on the work schedule of 10,500 m^3 of daily average embankment volume.

The same for the excavation works are based on 5,000 m^3 of daily maximum excavation volume.

Estimation of Capacity of Major Construction Machinery

Swell factor of volume change for each mateiral is assumed as follows:

Material	Loose/Bank	Embanked/Bank
Core	1.30	0.9
Filter	1.15	1.05
Rock	1.50	1.15

1) Bulldozer

a) Bulldozer, 32-ton Class
(Loading at quarry, excavation and spreading in dam construction)

$$Q = \frac{60.q.f.E}{Cm}$$

$$Cm = \frac{1}{V1} + \frac{1}{V2} + G$$

Where

Q	:	capacity, m^3/hr	
q	:	Volume per push 6.0 m^3	
f	:	load conversion factor 1.0	
E	:	work efficiency 0.80	
Cm	:	cycle time,(min.)	
l	:	haul distance	
		Excavation & spreading	50.0 m
		Loading at quarry	20.0 m
V	:	speed, forward	40.0 m/min.
		speed, backward	80.0 m/min.
G	:	time for gear shift	0.3 min.

l = 20 m.

$$Cm = \frac{20}{40} + \frac{20}{80} + 0.3 = 1.05 \text{ (min.)}$$

$$Q = \frac{60 \times 6.0 \times 1.0 \times 0.8}{1.05} = 270 \ m^3/hr \text{ (Loose)}$$

l = 50 m

$$Cm = \frac{50}{40} + \frac{50}{80} + 0.3 = 2.18 \text{ (min.)}$$

$$Q = \frac{60 \times 6.0 \times 1.0 \times 0.8}{2.18} \fallingdotseq 130 \ m^3/hr \text{ (Loose)}$$

b) Bulldozer 21-ton Class (Spreading)

q : 4.0 (m^3)
l : 50 (m)

$$Q = \frac{60 \times 4.0 \times 1.0 \times 0.8}{2.18} \fallingdotseq 85 \ m^3/hr \text{ (Loose)}$$

2) Power Shovel

a) Power Shovel, 1.2 m^3 Class (Excavation)

$$Q = \frac{3600.q.E}{Cm}$$

q : excavation & loading per cycle 1.05 (m^3)
E : efficiency 0.40
Cm: cycle time 20 (sec.)

$$Q = \frac{3600 \times 1.05 \times 0.40}{20} \fallingdotseq 80 \ m^3/hr.$$

b) Backhoe 1.2 m^3 Class (Excavation)

$$Q = \frac{3600.q.E}{Cm}$$

q : 1.05 m^3
E : 0.80
Cm: 30 (sec.)

$$Q = \frac{3600 \times 1.05 \times 0.80}{30} = 100 \ m^3/hr.$$

3) Dozer-Shovel and Wheel Loader

a) Dozer-Shovel, 2.0 m^3 Class (Loading)

$$Q = \frac{3600.q.k.f.E}{Cm}$$

Q : capacity, m^3/hr.
q : bucket capacity 2.0 m^3
k : bucket factor 0.75
f : load conversion factor 1.0
E : work efficiency 0.80
Cm: cycle time, (sec.)
Cm: $ml + t_1 + t_2$
l.: haul distance 15 m.
m : factor 2.0
t_1 : time per shovelling (10 sec.)
t_2 : time for gear shift (20 sec.)

Cm = 2.0 x 15 + 10 + 20 = 60 (sec.)

$$Q = \frac{3600 \times 2.0 \times 0.75 \times 1.0 \times 0.80}{60} \doteqdot 70 \ m^3/hr \ (Loose)$$

b) Wheel Loader, 3.1 m^3 Class (Loading)

q : 3.1 (m^3)
m : 1.8
t_1 : 15 (sec.)
Cm = 1.8 x 15 x 15 x 20 = 62 (sec.)

$$Q = \frac{3600 \times 3.1 \times 0.75 \times 1.0 \times 0.8}{62} \fallingdotseq 105 \ m^3/hr \ (Loose)$$

4) Dump Truck

a) Heavy Duty Dump Truck, 20-ton Class (Hauling)

$$Q = \frac{60.q.f.E}{Cm}$$

Q : haul capacity per hour, m^3/hr.
q : load capacity 13.0 m^3
f : load conversion factor 1.0
E : work efficiency 0.90
Cm : cycle time, (min.)

$$Cm = 60 \times D \times \left(\frac{1}{V1} + \frac{1}{V2} \right) + t$$

D : haul distance 1.9 (km)
V_1 : speed, full load 20 (km/hr)
V_2 : speed, empty 25 (km/hr)
t : total time for loading, unloading, turning waiting, etc. 10 (min.)

$$Cm = 60 \times 1.9 \times \left(\frac{1}{20} + \frac{1}{25}\right) + 10 = 20.3 \text{ (min.)}$$

$$Q = \frac{60 \times 13.0 \times 1.0 \times 0.90}{20.3} = 30 \ m^3/hr \text{ (Loose)}$$

b) Dump Truck, 8-ton Class (Hauling)

q : 5.0 (m^3)

$Cm = 4 \times D \times t \ (D \leq 1.0 \text{ km})$,

$$Cm = 60 \times D \times \left(\frac{1}{V1} + \frac{1}{V2} \right) + t$$

D : quarry 0.4 (km)
hauling 1.5 (km)
Waisting 1.0 (km)
t : 5 (min.)
D = 0.4
Cm = $4 \times 0.4 + 5 = 6.6$ (min.)

$$Q = \frac{60 \times 5.0 \times 1.0 \times 0.9}{6.6} = 40 \ m^3/hr \text{ (Loose)}$$

D = 1.0

$Cm = 4 \times 1.0 \times 5 = 9$ (min.)

$$Q = \frac{60 \times 5.0 \times 1.0 \times 0.9}{9.0} = 30 \ m^3/hr \text{ (Loose)}$$

D = 1.5

$$Cm = 60 \times 1.5 \times \left(\frac{1}{20} + \frac{1}{25} \right) + 5 = 13.1 \text{ (min.)}$$

$$Q = \frac{60 \times 5.0 \times 1.0 \times 0.90}{13.1} = 20 \ m^3/hr \text{ (Loose)}$$

5) Crawler Drill

a) Crawler Drill, CD-4 Class

Weight: 4,000 kg

Air consumption: 17 m^3/min.

Feed Length: 3,500 m/m

Rod: 38 m/m Hex.

Bit: 75 m/m

Drilling Speed: 0.20 m/min (incl. jointing of rods and re-location)

Bench Height: 10 m

Drilling Length: 12 m

Between Hole Centers: 3.0 m

Minimum Hole Distance: 3.0 m

Number of Drilling Hole per Hour:
60 x 0.20 ÷ 12.0 = 1

Capacity per hour: 12 x 3.0 x 3.0 x 1 = 108 m^3/hr (Bedrock)

6) Vibration Roller and Tamping Roller

a) Vibration Roller, 15-ton Class

$$Q = \frac{1000.V.W.H.f.E}{N}$$

Where

Q : work capacity per hour, (m^3/hr.)
V : work speed
Rock 2.0 (km/hr)
Filter 1.5 (km/hr)
W : effective compaction width 1.5 (m)
H : finish layer thickness
Rock 1.0 (m)
Filter 0.3 (m)
f : conversion factor 1.0
N : number of compaction 5
E : work efficiency 0.80

i) Rock Materials

$$Q = \frac{1000 \times 2.0 \times 1.5 \times 1.0 \times 1.0 \times 0.80}{5} = 480 \ m^3/hr$$ (Loose)

ii) Filter Materials

$$Q = \frac{1000 \times 1.5 \times 1.5 \times 0.3 \times 1.0 \times 0.8}{5} = 105 \ m^3/hr$$ (Loose)

b) Tamping Roller, 13.5-ton Class

$$Q = \frac{1000.V.W.H.f.E}{N}$$

Where

Q : work capacity per hour, m^3/hr.
V : work speed 3.0 (km/hr.)
W : effective compaction width 1.5 (m)
H : finish layer thickness 0.25 (m)
f : conversion factor 1.0
N : number of compaction 8
E : work efficiency 0.80

$$Q = \frac{1000 \times 3.0 \times 1.5 \times 0.25 \times 1.0 \times 0.80}{8} = 110 \ m^3/hr$$ (Loose)

<u>Number Required of Major Construction Machinery</u>

1) Bulldozer

Number required equipment is based on the volume of excavation in terms of volume of loose materials:

Bulldozer, 32-ton Class, equipped with ripper is used in a quarry area.

Bulldozer, 21-ton Class, is used in spreading of core and filter materials.

Heavy duty Bulldozer, 32-ton Class, is used for handling of rock materials.

a) Loading at Quarry (Bulldozer, 32-ton Class equipped with ripper):

i) Core Materials

Embankment volume 2,400 m^3 (daily average)

Loose volume $2,400 \times \frac{1.30}{0.9} = 3,470 \ m^3$

$3,470 \div 14 \div 270 = 0.9 = 1$ unit

ii) Filter Materials

Embankment volume $1,800\ m^3$ (daily average)

Loose volume $1,800 \times \frac{1.15}{1.05} = 1,970\ m^3$

$1,970 \div 14 \div 270 = 0.5 = 1$ unit

iii) Rock Materials

Embankment volume $6,300\ m^3$ (daily average)

Loose volume $6,300 \times \frac{1.50}{1.15} = 8,200\ m^3$

$8,200 \div 14 \div 270 = 2.2 = 3$ units

b) Dam Spreading

i) Core Materials (Bulldozer, 21-ton Class)

Embankment volume

Main dam	$1,200\ m^3$
Left wing dam	$650\ m^3$
Right wing dam	$550\ m^3$

Loose volume

Main dam $1,200 \times \frac{1.30}{0.9} = 1,750\ m^3$

$1,750 \div 14 \div 89 = 1.4 = 2$ units

Left wind dam $650 \times \frac{1.30}{0.9} = 940\ m^3$

$940 \div 14 \div 89 = 0.8 = 1$ unit

Right wing dam $550 \times \frac{1.30}{0.9} = 800\ m^3$

$800 \div 14 \div 89 = 0.6 = 1$ unit

Total number required equipment: 4 units

ii) Filter Materials (Bulldozer, 21-ton Class)

Embankment volume

Main dam	$900\ m^3$
Left wing dam	$500\ m^3$
Right wing dam	$400\ m^3$

Loose volume

Main dam	$900 \times \frac{1.15}{1.05} = 990\ m^3$
	$990 \div 14 \div 85 = 0.8 = 1$ unit
Left wing dam	$500 \times \frac{1.15}{1.05} = 550\ m^3$
	$550 \div 14 \div 85 = 0.5 = 1$ unit
Right wing dam	$400 \times \frac{1.15}{1.05} = 440\ m^3$
	$440 \div 14 \div 85 = 0.4 = 1$ unit

Total number required equipment: 3 units

iii) Rock Materials (Bulldozer, 32-ton Class)

Embankment volume

Main dam	$3,000\ m^3$
Left wing dam	$1,900\ m^3$
Right wing dam	$1,400\ m^3$

Loose volume

Main dam	$3,000 \times \frac{1.50}{1.15} = 3,400\ m^3$
	$3,900 \div 14 \div 130 = 2.1 = 3$ units
Left wing dam	$1,900 \times \frac{1.50}{1.15} = 2,500\ m^3$
	$2,500 \div 14 \div 130 = 1.4 = 2$ units
Right wing dam	$1,400 \times \frac{1.50}{1.15} = 1,800\ m^3$
	$1,800 \div 14 \div 130 = 0.9 = 1$ unit

Total number required equipment: 6 units

2) Dozer-Shovel and Wheel Loader

Dozer-Shovel, 2.0 m^3 Class, is used in loading of core and filter materials at quarry.

Wheel Loader, 3.1 m^3 Class, is used in loading of rock materials at quarry, and in loading of core and filter materials at stock-pile.

a) Loading at Quarry

i) Core Materials (Dozer-Shovel, 2.0 m^3 class)

Loose volume 3,470 m^3
3,470÷14÷70 = 3.5 = 4 units

ii) Filter Materials (Dozer-Shovel, 2.0 m^3 Class)

Loose volume 1,970 m^3
1,970÷14÷70 = 2.0 = 2 units

iii) Rock Materials (Wheel Loader, 3.1 m^3 Class)

Loose volume 8,200 m^3
8,200÷14÷105 = 5.6 = 7 units

b) Loading at Stock-Pile

i) Core Materials (Wheel Loader, 3.1 m^3 Class)

Loose volume 3,470 m^3
3,470÷14÷105 = 2.4 = 3 units

ii) Filter materials (Wheel Loader, 3.1 m^3 Class)

Loose volume 1,970 m^3
1,970÷14÷105 = 1.3 = 2 units

3) Dump Truck

Dump truck, 20-ton Class, is used in hauling of rock materials from quarry to dam site.

Dump truck, 8-ton Class, is used in hauling of core and filter materials from quarry to stock-pile and from stock-pile to dam site.

a) Hauling from Quarry to Dam site

i) Rock materials (Dump Truck, 20-ton Class)

Loose volume 8,200 m^3
8,200÷14÷30 = 19.5 = 20 units

b) Hauling from Stock-pile to Dam Site

i) Core Materials (Dump Truck, 8-ton Class)

Loose volume 3,470 m^3
3,470÷14÷25 = 9.9 = 10 units

ii) Filter Materials (Dump Truck, 8-ton Class)

Loose volume 1,970 m^3
1,970÷14÷25 = 5.6 = 6 units

c) Hauling from Quarry to Stock-pile

i) Core Materials (Dump Truck, 8-ton Class)

Loose volume 3,470 m^3
3,470÷14÷40 = 6.2 = 7 units

ii) Filter Materials (Dump Truck, 8-ton Class)

Loose volume 1,970 m^3
1,970÷14÷40 = 3.5 = 4 units

4) Crawler Drill

Crawler drill, CD-4 Class, is used for drilling prior to excavation of rock materials at quarry mountain.

Number of the required equipment is based on the volume of excavation in terms of the equivalent loose materials.

a) Rock Materials

i) Rock Materials

Embankment materials 6,300 m^3

Loose materials $6,300 \times \frac{1}{1.50} = 4,200$ m^3

4,200÷14÷108=2.7 = 3 units

5) Vibration Roller and Tamping Roller

Number of required equipment is based on the volume of excavation in terms of volume of loose materials.

For compaction of core materials, tamping roller, 13.5-ton Class, is used, and for compaction of filter and rock materials, vibration roller, 15-ton Class, is used.

a) Compaction

i) Core Materials (Tamping Roller, 13.5-ton Class)

Loose volume

Main dam 1,750 m^3
1,750÷14÷110 = 1.1 = 2 units

Left wing dam 940 m^3
940÷14÷110 = 0.6 = 1 unit

Right wing dam 800 m^3
800÷14÷110 = 0.5 = 1 unit

Total number required equipment: 4 units

ii) Filter Materials (Vibration Roller, 15-ton Class)

Loose volume

Main dam 990 m^3
990÷14÷105 = 0.7 = 1 unit

Left wing dam 500 m^3
500÷14÷105 = 0.3 = 1 unit

Right wing dam 400 m3
400÷14÷105 = 0.3 = 1 unit

Total number required equipment: 3 units

iii) Rock Material (Impact Roller, 15-ton Class)

Loose volume

Main dam 3,900 m3
3,900÷14÷480 = 0.6 = 1 unit

Left wing dam 2,500 m3
2,500÷14÷480 = 0.4 = 1 unit

Right wing dam 1,800 m3
1,800÷14÷480 = 0.3 = 1 unit

Total number required equipment: 3 units

Number of the required machinery and equipment is based on the volume of excavation; 50% by Bulldozer, 32-ton Class, equipped with ripper, and the balance of 50% by Backhoe, 12 m^3 Class.

Also, for waste hauling, dump truck, 8-ton Class, is used, and the factor of volume of loosened earth is computed at L=1.2.

i) Bulldozer, 32-ton Class, equipped with ripper

Excavation volume $5,000 \times 1/2 = 2,500\ m^3$

Loose volume $2,500 \times 1.20 = 3,000\ m^3$

$3,000 \div 14 \div 130 = 1.6 = 2$ units

ii) Backhoe, $1.2\ m^3$ Class

Excavation volume $5,000 \times 1/2 = 2,500\ m^3$

Loose volume $2,500 \times 1.20 = 3,000\ m^3$

$3,000 \div 14 \div 100 = 2.1 = 3$ units

iii) Dump Truck, 8-ton Class

Excavation volume $5,000\ m^3$

Loose volume $5,000 \times 1.20 = 6,000\ m^3$

$6,000 \div 14 \div 30 = 14.3 = 15$ units

4.5 Provisional Facilities

With the commencement of the work, requirement arises to establish or build the provisional facilities including quarter, offices, warehouses, motor pools, workshops, concrete mixing plants, aggregate stock piles, and working roads, etc.

A tentative layout of the facilities is shown in Fig. 1-21.

The required area is estimated to be about 7,000 m2. On the other hand, the contractor will require the temporary buildings and yards for offices, quarter, warehouse, laboratory, labour camps, motor pool, repair shop, steel work shop and others. Adding further 20,000 m^2 for batcher plant and aggregate plant, about 81,000 m^2 of land will be required for the contractor's use.

These required area is tentatively estimated as shown below:

Description	Estimated area (m^2) Building	Land
1) For government and engineer		
Employer's office	500	2,000
Employer's quarter	1,000	
Warehouse	450	5,000
Guards house	50	
Sub-total	2,000	7,000

Description	Estimated area(m^2) Building	Land
2) Contractor's facilities		
Office	800	1,500
Contractor's quarters	2,000	6,000
Labour camps	6,000	15,000
Material & parts warehouse	1,000	7,000
Cement warehouse	1,800	4,000
Motor pool and repair shop	700	20,000
Steel work shop	200	2,500
Carpentry shop	300	1,000
Miscellaneous	1,500	6,000
Sub-total	14,300	63,000

Concrete Batching and Mixing Plant

The total concrete required for the project is about 171,000 m^3. According to the construction time schedule, the peak concrete requirement is estimated to be 8,000 m^3/month occuring in the period of working at the spillway and the diversion conduits.

Assuming the operation efficiency of the plant to be 0.8, the monthly operation day and daily operation hour would be 21 days and 14 hours respectively. The required hourly production capacity of the plant is calculated to be:

$$\frac{8,000}{21 \times 14 \times 0.8} = 40 \ m^3/hr.$$

Further, assuming that the mixing time per batch is 3 minutes, the required mixer capacity of the plant is estimated at:

$$\frac{40 \times 3}{60} = 2 \ m^3$$

And, the mixer of the batcher plant is determined to be two 1.0 m^3 mixer.

Aggregage Screening Plant

The plant is of the simple type equipped with primary crusher, several stage vibrating screens, classifier and other accessories.

Daily concrete placement volume 500 m^3

Daily aggregate requirement $500m^3 \times 2.1ton = 1,050$ tons

Daily operation hour 14 hours

Working efficiency 0.6

Required plant capacity $\frac{1.50 \text{ tons}}{14 \text{ hrs} \times 0.6} = 125$ ton/hr.

Water Supply for Construction

Construction water requirement is estimated as follows:

Location	Requirement
Aggregate plant 125 ton/hr	3.0 m^3/min
Concrete plant 1 m^3 x 2	0.5
Repair shop	0.8
Motor pool & storage yard	1.0
Warehouses and shops	0.2
Office	0.1
Government living quarters	0.2
Contractor's living camp	0.1
Labour's camp	0.3
Damsite work area	2.0
Diesel generating plant	1.0
Others	1.0
Total	10.2 m^3/min

Water is taken from the river, pumped up to head tanks through 300 mm dia. pipeline, and distributed to each delivery point for the main supply systems on the left bank at the Main dam.

Power Supply for Construction

Electric power generated by 2 units of 500 kW diesel generator is distributed to each site by 20 kV distribution line.

The peak requirement of power is totalled to 700 kW assuming the power demand factor of 0.45. In usual case, one generator can supply enough power to the work sites.

Location	Power requirement
Aggregate plant 125 ton/hr.	200 kW
Concrete plant 1 m^3 x 2	50
Water supply	300
Lighting, damsite and road	100
Repair shop	100
Motor pool & work shops	50
Office & quarters	150
Dewatering pump	100
Others	450
Total	1,500 kW

Transportation Facilities

Construction equipment and materials are mostly to be land-carried from Ujung Pandang to the dam site which is located about 31 km away from the city. While 8.3 m wide asphalt road on both sides of the center belt are made available inside the city of Ujung Pandang, the distance from which is asphalt paved to the width of 5 m, plus 1.5 m sideways along its shoulders. On its way to the dam site, 4 small bridegs have to be crossed over; although their span is less than 5 m, no particulars strengthening or relocation is deemed necessary.

Road Relocation nearby the Dam site

The section of Jl. Malino which is running on the right bank of the proposed dam needs to be closed since an early part of the diversion work; it is therefore necessary to relocate it immediately upon commencement of the work. The remaining relocation work can be taken up along the dam construction progress.

4.6 Cost Estimate

Construction Cost

The total construction cost of Bili-Bili dam comprise civil works, gates and equipment, road relocation, land acquisition, engineering cost and plus 15% physical contingencies.

The total cost will be US$157.2 million, out of which US$79.5 million is of foreign currency and 77.7 million of local currency.

The breakdown of the construction cost is shown in Table 1-9, and the annual disbursement schedule in shown in Table 1-10.

Operation, Maintenance and Replacement Cost

The dam operation and maintenance cost will comprise the personnel cost, operational machinery and equipment, vehicles, boats, administrative cost and miscellaneous. As an annual operation and maintenance cost for the whole period of the project life, US$0.08 million is estimated. Replacement cost of the gates after 35 years from the initial dam operation has been estimated at US$1.47 million.

5. ENVIRONMENTAL ASSESSMENT

5.1 Dam's Neighborhood

Natural Environment

With regard to topography, climate and hydrology, reference to natural environment has already been made in the foregoing Chapter. Concerning sedimentation, the review of the study previously made under the "Lower Jeneberang Flood Control Project, 1980" has resulted at the following findings on the average annual sediments:

One of sediment discharge of 1,500 $m^3/km^2/year$, about 90% of the sediments flown down from the upper stream consists of wash load which mainly originates in the collapse area (0.2 km^2 wide, with an average gradient of 0.95, as shown in Fig. 1-23) as well as the deposits on the banks of the river channel. Wash load tends to be produced in a concentrated manner at the time of rain as has been observed that the river water turns muddy by a comparatively high density of wash load with 0-5 cm transparency in case of rain, while the river-water resumes transparency of 30-50 cm when it does not rain.

Vegetation in the upper stream of the proposed damsite can be described as follows: Almost 80% of the basin is covered by Aran-Aran and a few tall trees made up of mango, bamboo, and betel palm, etc., while approximately 13% of the remaining 20% is made up of the grassland, including small denuded area, and the farmland is restricted to the flood deposit area along the river channel only.

Wild animals encountered there are mostly sheep or deers and monkeys, with no trace of any other special animals. There is no record available as to the existence of archeological relics or mineral resources in the area concerned.

Social Environment

Administratively speaking, the upper stream of the proposed dam site belongs to Kec. Parang Loe, Kab. Gowa in South Sulawesi province. This area is dotted with such villages as Kp. Bujula, Kp. Tonalenasde, and Kp. Pong, etc., which mainly consists of the people engaged in agriculture and forestry. Table 1-11 shows the age bracket distribution of the inhabitant in the said villages and it is recognized that the age group of less than 30 years old holds 70% of the gross generation. By religion, they are predominantly Muslim and ethnically, the Makassarese, usually speaking the Makassarese language.

Jl. Malino, a single trunk road connecting Ujung Pandang with Malino is running along the right bank of the Jeneberang river.

5.2 Environmental Impacts due to Dam Construction

Major impacts presumed by dam construction may be itemized as follows:

1) Submersion of houses, fields and roads under the reservoir,

2) Deposit of sediments in the reservoir, which may cause the elevation of the riverbed in the upstream of the reservoir and the muddiness of the reservoir water due to wash load.,

3) Maintenance water in the downstream during a dry season,

4) Direct impacts due to the dam construction work, which may cause the muddiness of the river water in the downstream and the alteration of topography around the dam site, and

5) Impacts on fauna and flora.

5.3 Assessment of and Countermeasure to the Environmental Impacts due to Dam Construction

Some of the more problematic of the environmental impacts submitted in the above will be individually assessed. Consequently, it has been concluded that there seems to exist no particular reason to suspect occurrence of the serious problems due to construction of the dam as discussed in the below;

<u>Submersion of Houses, Fields and Roads under the Reservoir</u>

The houses requiring the submersion compensation are counted at 800 approximately and located in eight villages dedicated in Fig. 1-24, namely Kp. Bujula, Kp. Jene Madinging, Kp. Tona Tonasal, Kp. Bende Sunggu, Kp. Bonto Parang, Kp. Kaballokang, Kp. Parang and Kp. Porang. These villages need the transfer with the whole their communities due to the submergence of the greater part of the village. The transfer of the inhabitants shall be arranged by paying attention to their ethnical, linguistic and educational aspects so that the existing patterns of their community may not be seriously disturbed thereby.

Following the above transfer of the inhabitant, the major means for living should be kept in the form of keeping the present condition. The major means for living is composed of the paddy and useful plans production. There exist 6.6 km^2 of paddy field area in the submergence area, of which a greater part lays along the river. As for the useful plans, the fruit trees like the copura and the bamboo trees which are used for the paper manufacture material at Gowa paper Public Corporation are enumerated and should be also the objects requiring the submersion compensations. In this addition, the existing pumping station for the mulberry plantation which is located at the proposed dam site is required to be replaced.

Elevation of the Riverbed in the Upstream of the Reservoir

As shown in the conceptual diagram given in Fig. 1-25 the sedimentation distribution form at the upstream of dam will be composed of "Bottom-set beds", "Fore-set beds" and "Top-set beds". The said top-set and fore-set beds generally crawl up to the upstream as sedimentation progresses and cause the elevation of the riverbed in the upstream of the dam site through the phenomenon called "back sand". The bed material loads which is typical of the bigger dimensional load tend to be deposited in the upstream of the reservoir and the wash loads, the smaller dimensional one tend to be in the reservoir. Accordingly the bed material loads hold the greater part of the top-set and fore-set beds located in the upstream of the reservoir with least deposit of wash load. As reported in the foregoing sub-section, 90% of sediments in this river basin consists of wash loads and the content of bed material loads is extremely small. In such case, the top-set and fore-set beds will lose their own clear distinction and an elevation of the river bed in the upstream due to "back sand" effect will be of no serious consequence.

The definite influence of the back sand is examined by the following calculation:

Assuming that the maximum value of the annual sediment of bed material load amounting to 140 m^3/km^2/year (refer to "Lower Jeneberang Flood Control 1980") will be deposited entirely on the top-set bed and the gradient of the top-set bed as 70% of the original riverbed, as usually adopted in such estimation, the top-set bed volume in the future of 100 years will be estimated as follows:

Back sand volume	:	5.4×10^6 m^3
Extent affected by back sand	:	1.4 km
Maximum water stage at flow discharge of 4,300 m^3 (=1,000 year return period)	:	2.0 m

(The above estimation depends on the non-uniform calculation and Fig. 1-26 shows the longitudinal profile of water stage which is calculated under the above-mentioned condition.)

Accordingly, the water level may possibly be raised by less than 2 m or so due to the elevation of riverbed caused by "back-sand" but, fortunately, there exists no important object to be affected by such an elevation of the water level. It is consequently assessed that the impact of "back-sand" resulting from dam construction is not serious.

Muddiness of the Reservoir Water due to Wash Load

As already mentioned, about 90% of the annual average of sediments depositable on the riverbed consists of wash load which reaches to a comparatively high density, making the river water near the dam site muddy, at the time of rain. It might, therefore, be suspected if muddiness of the reservoir water caused by wash load could or could not give undesirable effects on the facilities meant for transmission of the municipal water and/or discharge of the irrigation water, after completion of the dam. In this connection, it is reasonably expected that a majority of muddy water flowing into the reservoir during a flood will be swiftly discharged through operation of the movable gates (capacity 500 m^3/s) or over the free flow weir at the spillway, without lingering inside the reservoir. Morever, discharge of muddy water due to rainfall seldom lasts for more than 5 days to be immediately followed by inflow water with fairly high transparency; judging from these characteristics of this river, the muddiness of the reservoir water will subside in no time. Again, 258,000,000 m^3 of the utility water which is allocated in the reservoir is expected to dilute muddy water to a great extent.

Accordingly, it is assessed that the impact of muddiness of the reservoir water is almost negligible.

Maintenance Water in Downstream during Dry Season

In this basin, dry season generally lasts from May to October, with a certain time-lag year to year, almost 3 months of which sees low water discharge at around 3 m^3/s.

The river water volume of more than 2 m^3/s is presently taken for irrigation at Bili-Bili and Kampili intake during the said dry season.

The river water volume after being taken for irrigation is therefore, reduced to almost none for a considerably long period of time in each dry season. According to the field investigation, there exists only 0.5 m^3/s of river water approximately in the downstream of Kampili intake, which is further allotted to the vested water rights. Therefore, there exist almost none for the maintenance water of the river itself in the downstream of Kampili intake.

Meanwhile, the proposed dam project has a plan to the assure the constant dam-regulated water of 0.5 m^3/s in the downstream of Kampili intake. However, the assured river water is not prepared for the pure maintenance water but for the aforementioned vested water rights.

Post-project (after dam construction) dry season flow regime in the downstream of Kampili intake has been estimated on the basis of the data relating to 1976, 1977 and 1979 which were selected because of comparative longer water shortage periods, as follows:

Numbers of Days Distributed by River Discharge Range
(after Kampili Intake)
(May to October) (Unit: days)

Discharge Range	Less than $0.5m^3/s$		$0.5m^3/s$ - $10m^3/s$		More than $10m^3/s$	
	Current	Post-Proj	Current	Post-Proj	Current	Post-Proj
Year 1976	158	153	5	10	21	21
1977	154	154	6	10	24	20
1978	154	159	5	5	25	20

Eventually, the flow regime during the low water period after dam construction will remain almost the same at present. However, judging from the fact the river water is not indispensable for day-to-day living of the people along the lower reaches of the Jeneberang River, apart from the vested water rights amounting to 0.5 m^3/s, no problem in particular will arise from such a prospect as long as the current situation may not be turned worse.

Abrupt Elevation of River Water Level in Downstream due to Extraordinary Flood Discharge

Compared with the present condition, the proposed dam will never cause the abrupt elevation of river water level in downstream even during the extraordinary flood, because a free flow section is adopted to the spillway of dam.

Therefore, no countermeasure such as a warning system for the said problem is necessary.

Contamination of the River Water during Dam Construction Period

It is feared that the river water may be contaminated with a great volume of silt which will come out in process of mining the river bed to get the aggregate and mixing the concrete.

The abundant living water drained by the dam constructors may also cause the pollution of the river water and the spread of the epidemic.

Considering the above problems the following countermeasures will be necessary during the dam construction:

The mining of the riverbed in the flowing water should be avoided by preparing the temporary diversion channel. The water-works and drainage-works should be carried out and it is necessary to prepare the monitoring system among the dam constructors in order to detect the epidemic in its early stages and carry out the isolation of patients and the disinfection.

Topographical Transformation due to the Dam Construction

The topography around the dam site will be transformed by the construction of the access roads or the mining of the aggregate. However, it is judged that there never exist any serious problems because of the replacement of the surrounding communities of the dam reservoir.

Impacts on Fauna and Flora

The covering area of the reservoir is only 17.8 km^2 corresponding to only 4.6% of upper reaches of the dam site and there doesn't exist any urgent necessity to protect the forest or the animal presently in the project area.

Considering above, it is estimated that there never exist any problems regarding the impacts on the terrestrial fauna and flora.

As for the aquatic fauna and flora, the more appropriate condition will spring from the breeding of algae and the enlargement of the living area given by the reservoir. In the downstream of the dam site, the smooth stream regimen depending on the dam regulation will further give a good condition to the aquatic fauna and flora.